SCRUB COMMUNITY DESCRIPTIONS OF THE BAJA CALIFORNIA PENINSULA, MEXICO

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ABSTRACT

Qualitative and quantitative data on woody and succulent plant distribution in Baja California, Mexico were collected from 17 January to 21 February, 1991. Qualitative data from 196 samples were then clustered using TWINSPAN, a divisive, polythetic classification program. Fourteen scrub and woodland plant communities are described quantitatively using line-transect data. This is the first quantitative description of scrub plant communities for most of the peninsula. We compared our results with previous classifications and found close agreement in the California Floristic Province of Baja California (northwest). Comparisons were mixed in the Sonoran Desert region, suggesting more complicated mosaic species distributions. In the Sonoran desert, there was a general trend of increasing tree cover correlated with increasing rainfall from north to south. Vegetation maps at 1:250,000 and 1:1,000,000 scales produced in Mexico exist for Baja California. We compared our classification scheme to that used in these maps by first subjectively grouping our samples according to the Mexican scheme. We compared these data with data from the TWINSPAN analysis using indices of similarity. There is little agreement between the two classification schemes. The Mexican scheme, based on dominant life forms, is broader in scope and approximates vegetation types described here only in northern Baja California. Mapping units are poorly defined and there are many inconsistencies among maps. While these maps are a potentially rich source of information, we suggest that they be used only as a general guide to life forms of Baja California.

RESUMEN

Se colectaron datos cuantitativos y cualitativos sobre la distribución de plantas leñosas y suculentas de la Península de Baja California, México, del 17 de enero al 21 de febrero de 1991. Los datos cualitativos, obtenidos de 196 muestras, fueron clasificados mediante el uso del programa TWINSPAN, programa divisivo y polifilético. Para gran parte de la península, ésta es la primera descripción cuantitativa que se realiza. En lo que respecta a la Provincia Florística de California (noroeste de Baja California) los resultados concordaron estrechamente con previas clasificaciones. Sin embargo, en la región del Desierto Sonorense, se obtuvieron concordancias mezcladas por lo que se sugiere la ocurrencia de un mosaico de distribuciones de especies mas complejo. En el Desierto Sonorense se encontró una tendencia general al incremento en cobetura arbórea correlaciorada con el incremento en precipitación pluvial que se observa de norte a sur. Se describe brevemente el esquema de clasificación utilizado en los mapas de vegetación escala 1:250,000 y 1:1,000,000 editados por el gobierno Mexicano. Nuestras muestras fueron clasificadas subjectivamente de acuerdo al esquema Mexicano, y comparadas con los resultados del TWINSPAN utilizando una matriz de similitud. Los resultados de ésta indican poca concordancia entre los dos esquemas de clasificación. El esquema Mexicano, basado en formas de vida

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dominantes, es de escala más amplia y coincide con las comunidades vegetales aquí descritas, sólo en el noroeste de Baja California. Las unidades cartográficas de los mapas no están bien definidas y existen numerosas inconsistencias entre ellos. Sugerimos por tanto que estos mapas sean utilizados solamente como una guía general de las formas de vida vegetales de Baja California.

Vegetation classification and descriptive work in the Baja California peninsula, Mexico (hereafter referred to as Baja California), have been largely qualitative in nature (e.g., Shreve 1951, 1942, 1936; Wiggins 1980, 1969, 1960; Epling and Lewis 1942; Turner and Brown 1982; Hanes 1977; Mooney 1977; Axelrod 1978; Leon de la Luz et al. 1991). The most widely held general classification scheme divides Baja California into eight major plant associations (Wiggins 1980), including the Sonoran Desert communities of Shreve (1951). Turner and Brown (1982), in their treatment of the Sonoran Desert, use the classification scheme of Shreve (1951) and propose numerous types (termed series) within each of the seven Sonoran Desert divisions. Several quantitative vegetation classification studies have been performed in the Californian Floristic Region of Baja California (Westman 1983, 1981; Mooney and Harrison 1972). Quantitative work in the central desert region has been restricted to localized habitat descriptions with line-transect data (Turner and Brown 1982; Humphrey 1974). Plant communities in Baja California Sur north of the Cape region have not yet been studied quantitatively, and no quantitative treatment exists for the peninsula on a large scale.

The main purpose of this study is to provide a quantitative landscape-level classification scheme of perennial vegetation within the scrub communities of most of Baja California. Scrub communities are defined here as lower elevation (generally below 1000 m) vegetation composed primarily of deciduous or evergreen shrubs with total cover not exceeding 90%. Excluded from this work is "hard" chaparral, a dense largely evergreen community common in higher elevations of the Sierra Juarez, Sierra San Pedro Martir and also found in isolated patches in smaller mountain ranges within the Sonoran Desert. Also excluded from this study are scrub communities east of the peninsular range, in the Cape region (S of 24°N), and on the islands in the Gulf of California and the Pacific. These plant communities are well described elsewhere (see Felger and Lowe 1976; Cody et al. 1983; Moran 1983; Arriaga and Leon 1989). The Gulf Islands exhibit very similar plant species composition to the mainland and can even be considered samples of mainland flora and vegetation of comparable area (Cody et al. 1983).

The Mexican government has produced vegetation maps for Baja California at two scales, 1:1,000,000 (Instituto Nacional de Estadistica, Geografia y Informatica [INEGI] 1981) and 1:250,000 (INEGI 1980–1988). Another goal of this paper is to evaluate the accuracy and usefulness in the field of these maps. These maps are extremely detailed and cover every region of the peninsula, providing a potentially valuable source of information for vegetation scientists. The methodology used to produce these maps, one based on life-form, may not be consistent with more traditional quantitative methods of vegetation analysis. However, vegetation classification based on floristics, such as that presented here, can be highly complementary to that of the structural or life-form classification used in the Mexican maps (Mueller-Dombois and Ellenberg 1974). In order to assess the compatibility between our classification and that for which excellent mapping is available, a direct comparison between the two classification systems is made. Floral nomenclature follows that of Wiggins (1980) except for recent revisions to the genera *Euphorbia* (Huft 1984), *Viguiera* (Schilling 1990), and *Agave* (Gentry 1978). Place names follow INEGI (1978).

Study Site and Methods

In the northwestern region of the peninsula the climate resembles semiarid Mediterranean regions of southern California. Precipitation averages from 130 mm per year at sea level to over 250 mm at 550 m, over 95% of which falls from October to April. Mean January and July temperature is about 12°C and 25°C, respectively (Pase and Brown 1982). South of the peninsular range (30°N) the climate gradually shifts from arid to subtropical, with mean annual precipitation ranging from 50 mm in the north to just over 450 mm in the Cape region. North of the Cape, however, rainfall generally does not exceed 200 mm per year. The western side of the peninsula is generally wetter than the east due to the cooling effect of the California current and the prevalence of coastal fog. On the gulf side and in the southern portion of the peninsula, most rainfall occurs from July to October in the form of tropical storms. Elevations within the study region range from 0–2100 m (the highest mountains are over 3000 m). Soils are generally granitic in origin in the north and volcanic in origin in the south. For a detailed description of the peninsula's complex climate and physiography, see Wiggins (1980), Turner and Brown (1982), Pase and Brown (1982), Roberts (1989) and references therein.

Surveys were performed from 17 January through 21 February, 1991 along 2370 km (1481 mi) of paved and dirt roads as far south as Ciudad Insurgentes (24°N). Transects were located at five-road-mile intervals, on alternating sides of the road. Habitats typical of higher elevation (e.g., dense chaparral dominated by evergreen sclerophyllous shrubs), very low scrub communities (<0.5 m tall), grasslands, or sites with heavy disturbance were not sampled. A few other points were skipped when access was not possible within one mile of the five-mile mark. A total of 196 transects were taken along the survey route.

Vegetation sampling. Floristic composition was determined quantitatively by the use of a 30 meter long line transect following the method of Strong (1966). These began approximately 200 meters from the edge of the disturbed area along the road. Line transects ran perpendicular to the road except when they fell on slopes, in which case they were taken parallel to the slope axis. If the transect fell within a drainage, the transect was taken perpendicular to the drainage. For each transect, the length along the line and maximum width perpendicular to the line of all woody and succulent plants intercepted by the meter tape (with a minimum of 10 cm of material from one plant crossing the line) were recorded. Species density, dominance, frequency, and importance value were then calculated for each transect (Cox 1985). More detailed quantitative measures would have been desirable at each sample area (e.g., Westman 1981; McAuliffe 1990). However, given the time limitations of this survey and the large area over which it had to be performed, the combination of detailed qualitative descriptions and small-scale quantitative data averaged over a larger area were judged to yield the most accurate concept of vegetation patterns.

After the quantitative data were collected, the surveyor began a random walk to record (or collect if unknown; voucher specimens deposited at SDNHM) all perennial woody or succulent species within unaided visual range. At each site, cover estimates (crown diameter) of perennial vegetation were made. We used a modified Daubenmire (1959) cover class for each of four vegetation strata: (1) open space/rock outcrop/herbaceous, (2) small shrubs (<1.5 m tall), (3) large shrubs, and (4) trees. Plant habit rather than height distinguished the latter classes, as many short-statured trees are present in desert vegetation. The most conspicuous species in each of these layers were recorded as dominants (maximum of four) along with all other perennial species present that could be located within 30–40 minutes. In almost all cases, this was adequate time to identify all but the rarest woody and succulent species.

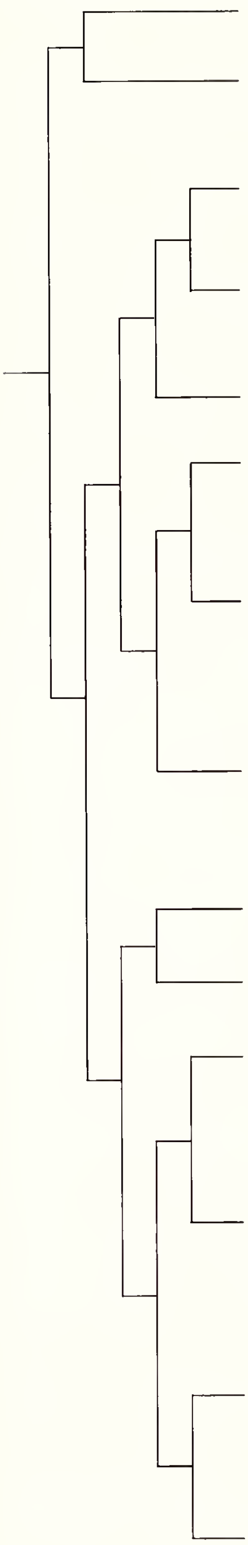
Vegetation classification. Each sample was first classified subjectively using the qualitative information found on Mexican vegetation maps (INEGI 1980–1988). These plant associations were then grouped into 12 higher level vegetation types and compared to vegetation types of the independent computer analysis with a matrix of similarity. Computer classification was based on data from the qualitative surveys only. Dominant species of each strata were given a score of two and all other species present were give a score of one. This gave equal weight to dominant species of different vegetation strata, regardless of their relative cover or abundance. Classification was based on species composition of the different strata rather than their absolute or relative abundances. Thus, each stratum was represented, even if it comprised a small portion (in terms of dominance and/or density) of the vegetation type. This equal weighting may more accurately distinguish important structural vegetation differences. For example, in many desert plant communities in Baja California, trees are uncommon in the landscape and would be a small part of any total cover value. However, they probably represent a disproportionately more important component (e.g., as avian habitat). However, in some cases, this asymmetric weighting may place excessive emphasis on rare but visually conspicuous species (e.g. *Pachycereus pringlei, Stenocereus thurberi, Idria columnaris*).

Classifications were based on the results of TWINSPAN (Two-Way Indicator Species Analysis), a polythetic, divisive classification scheme that uses the technique of reciprocal averaging to ordinate stands, producing a hierarchical tree (Hill 1979; Gauch 1982; Causton 1988). Classifications were based on a weighting of four to one for "conspicuous" versus "present" species. Absolute plant abundances were omitted from the TWINSPAN classification in favor of two abundance classes because a comparison of qualitative and quantitative data indicated that open cover was consistently underestimated in the qualitative surveys. This does not necessarily result in a loss of information. Given the degree of variation inherent in most species' spatial distribution, detailed measurements on species abundance for the purposes of large scale classification are usually unnecessary (Gauch 1982). Nine outlier transects were eliminated from this analysis. These included transects that fell in small drainages which were later pooled with adjacent more widespread vegetation type. Once the vegetation classification was determined, data from line transects were grouped accordingly. Species densities, dominance and frequency were averaged within vegetation types to arrive at a quantitative estimate of vegetation composition. Due to the small amount of quantitative sampling within each vegetation type (one 30-meter transect every five miles), the quantitative results should be used only as a guide. Indicator species were determined from TWINSPAN output with refinements based on quantitative results. Twenty-one plants that could not be identified to the species level were omitted from indicator status. Vegetation types were compared using a matrix of similarity.

Results

Vegetation classification. A total of fourteen scrub communities are described in this paper. The final dendrogram, including characteristic species ("indicator species") and dominants for these TWINSPAN classifications, are shown in Figure 1. Indicator species are not necessarily the dominant or most common species in the

FIGURE 1. CLASSIFICATION DENDROGRAM. Hierarchical tree produced by TWINSPAN. Sample sizes, vegetation type indicator and dominant species are also included. See text for explanation of indicator species.



Dendrogram	Habitat type	Sample points	Indicator species
	Diegan coastal sage scrub	23	*Artemisia californica, Viguiera laciniata, Malosma laurina*
	Martirian coastal succulent scrub	15	*Stenocereus gummosus, Agave shawii* ssp. *shawii, Ambrosia chenopodifolia*
	Central Vizcainan mixed scrub	17	*Stenocereus gummosus, Opuntia cholla, Pedilanthus macrocarpus, Idria columnaris*
	Sonoran creosote-bursage scrub	22	*Ambrosia magdalenae, A. dumosa, Opuntia echinocarpa, Idria columnaris*
	Vizcaino Plain desert scrub	5	*Encelia halimifolium*
	Rosarian coastal mixed scrub	6	*Agave shawii* ssp. *shawii, Stenocereus gummosus, Euphorbia misera, Frankenia palmeri, Ambrosia chenopodifolia, Idria columnaris*
	Northern Vizcaino Plain mixed scrub	4	*Agave shawii* ssp. *goldmaniana, Euphorbia misera, Frankenia palmeri, Ambrosia chenopodifolia, Idria columnaris, Pachycormus discolor*
	Vizcainan foothill desert scrub	7	*Atriplex julacea, Fouquieria diguetii, Agave shawii* ssp. *goldmaniana, Idria columnaris, Pachycormus discolor*
	Inland Gulf coast desert scrub	10	*Stenocereus thurberi, Jatropha cinerea, J. cuneata*
	Magdalenan coastal dune scrub	22	*Asclepias masonii, Lophocereus schottii, Jatropha cinerea*
	Central Gulf coast desert scrub	24	*Jatropha cuneata, Cercidium microphyllum, Bursera microphylla, Pedilanthus macrocarpus, Larrea tridentata, Stenocereus thurberi*
	Southern Gulf coast desert scrub	17	*Jatropha cuneta, Cercidium microphyllum, Lysiloma candida, Bursera microphylla, Ruellia californica, Olneya tesota, Stenocereus thurberi*
	Basaltic desert woodland	9	*Jatropha cuneata, Cercidium praecox, Prosopis palmeri, Euphorbia californica, Stenocereus thurberi*
	Basaltic desert scrub	6	*Jatropha cuneata, Cercidium praecox, Acacia brandegeana, Stenocereus thurberi*

FIGURE 1. EXTENDED.

Dominant species
Eriogonum fasciculatum, Viguiera laciniata, Artemisia californica, Salvia munzii
Rosa minutifolia, Ambrosia chenopodifolia, Agave shawii shawii, Euphorbia misera
Ambrosia chenopodifolia, Eriogonum fasciculatum, Larrea tridentata, Opuntia cholla, Fouquieria splendens
Larrea tridentata, Ambrosia chenopodifolia, Ambrosia dumosa
Encelia halimifolium, Larrea tridentata, Prosopis glandulosa var. *torreyana, Lycium bierlandei, Stenocereus gummosus*
Euphorbia misera, Agave shawii shawii, Ambrosia chenopodifolia, Atriplex polycarpa, Frankenia palmeri
Frankenia palmeri, Bursera microphylla, Ambrosia chenopodifolia, Euphorbia misera, Agave shawii goldmaniana
Lycium sp., *Fouquieria diguetii, Agave shawii goldmaniana, Euphorbia misera, Atriplex julacea*
Larrea tridentata, Ambrosia deltoides, Opuntia cholla, Stenocereus gummosus, Fouquieria diguetii
Lycium sp., *Fouquieria diguetii, Stenocereus gummosus, Jatropha cinerea, Larrea tridentata, Opuntia cholla*
Jatropha cuneata, Fouquieria diguetii, Ambrosia bryantii, Ambrosia camphorata
Jatropha cuneata, Bursera microphylla, Fouquieria diguetii, Ruellia peninsularis, Ruellia californica, Cercidium microphyllum, Lysiloma candida
Prosopis palmeri, Jatropha cuneata, Lycium sp., *Cercidium praecox, Opuntia cholla*
Jatropha cuneata, Fouquieria diguetii, Bursera microphylla, Larrea tridentata, Opuntia cholla

vegetation type. However, the presence of at least two of these indicators, plus the habitat's overall geographical extent, should be sufficient to distinguish the vegetation types in the field as they are defined here. Because many of the vegetation types are distinguishable from location alone, the indicator species listed are meant to aid in the differentiation of types that occur in close proximity. A comparison of species composition among the vegetation types is shown in Table 1. The location of sample sites supporting these vegetation types are shown in Figures 2 and 3. In the interest of space, only dominance values for 187 perennial species encountered are present here (Appendix 1).

Californian region. Two widespread scrub communities are present in this coastal region. The northernmost, Diegan coastal sage scrub (DCSS) (sensu Westman 1983), is characterized by the presence of two small shrubs, the drought-deciduous *Artemisia californica* and the evergreen *Viguiera laciniata,* and one larger shrub, *Malosma laurina.* Total cover is approximately 50%. This vegetation type is found along the coast from the international border just south of San Vincente at elevations up to 640 m (2100 ft.).

Martirian coastal succulent scrub (MCSS) (sensu Westman 1983) is found from just north of Colonet along the coast to San Quintín. This vegetation type is also present east of El Rosario and this area may be contiguous with MCSS along the coast via inland areas not surveyed. This type differs markedly from DCSS in that succulent species have a higher dominance and species richness. The most common of these are *Agave shawii* ssp. *shawii, Euphorbia misera,* the prostrate cylindrical cactus *Stenocereus gummosus,* and the treelike cactus *Myrtillocactus cochal. Rosa minutifolia,* a small densely-branched spiny shrub, sometimes grows in almost pure stands within this vegetation type. This vegetation type has the largest total dominance of any scrub community in this analysis (54.2%).

Sonoran Desert. Between San Quintín and El Rosario is Rosarian coastal mixed scrub (RCMS), a vegetation type that appears transitional between the Californian region to the north and the Sonoran desert to the south and east. This type is allied more closely (albeit weakly) with the Sonoran desert vegetation types and is characterized by the presence of elements of both communities (see Appendix 1). Largely Sonoran Desert species such as *Idria columnaris* and *Opuntia cholla* also become common in this vegetation type.

Ten vegetation types in this study clearly lie within the boundaries of the Sonoran Desert (including RCMS). The two southernmost types may or may not be part of the Sonoran desert region and are discussed later. Two of the northernmost types, Central Vizcainan mixed scrub (CVMS) and Sonoran creosote-bursage scrub (SCBS), occupy the central highlands region between approximately 30°N

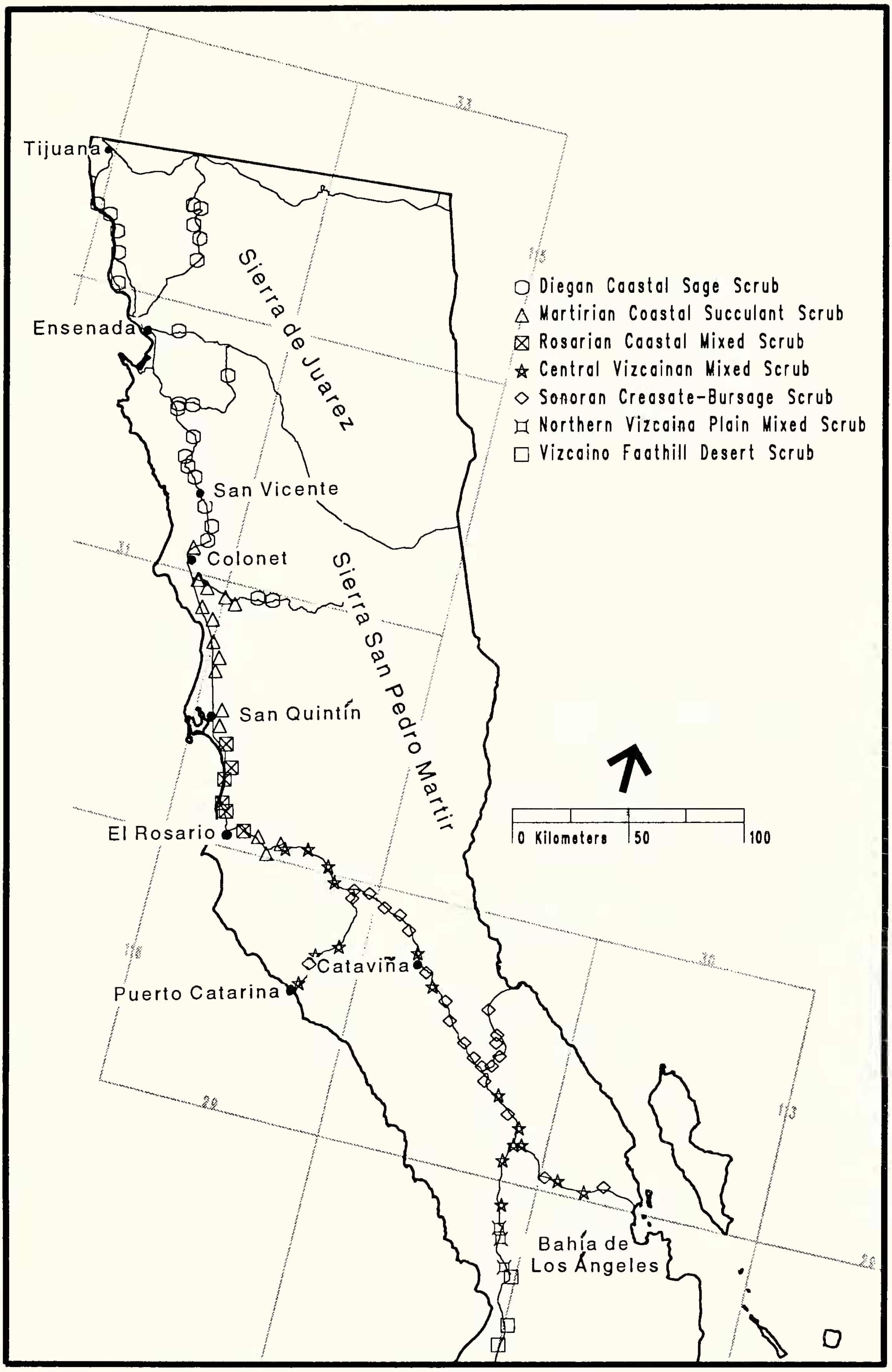


FIG. 2. Transect locations and vegetation types for Baja California. Names of places and topographical features mentioned in the text are also given.

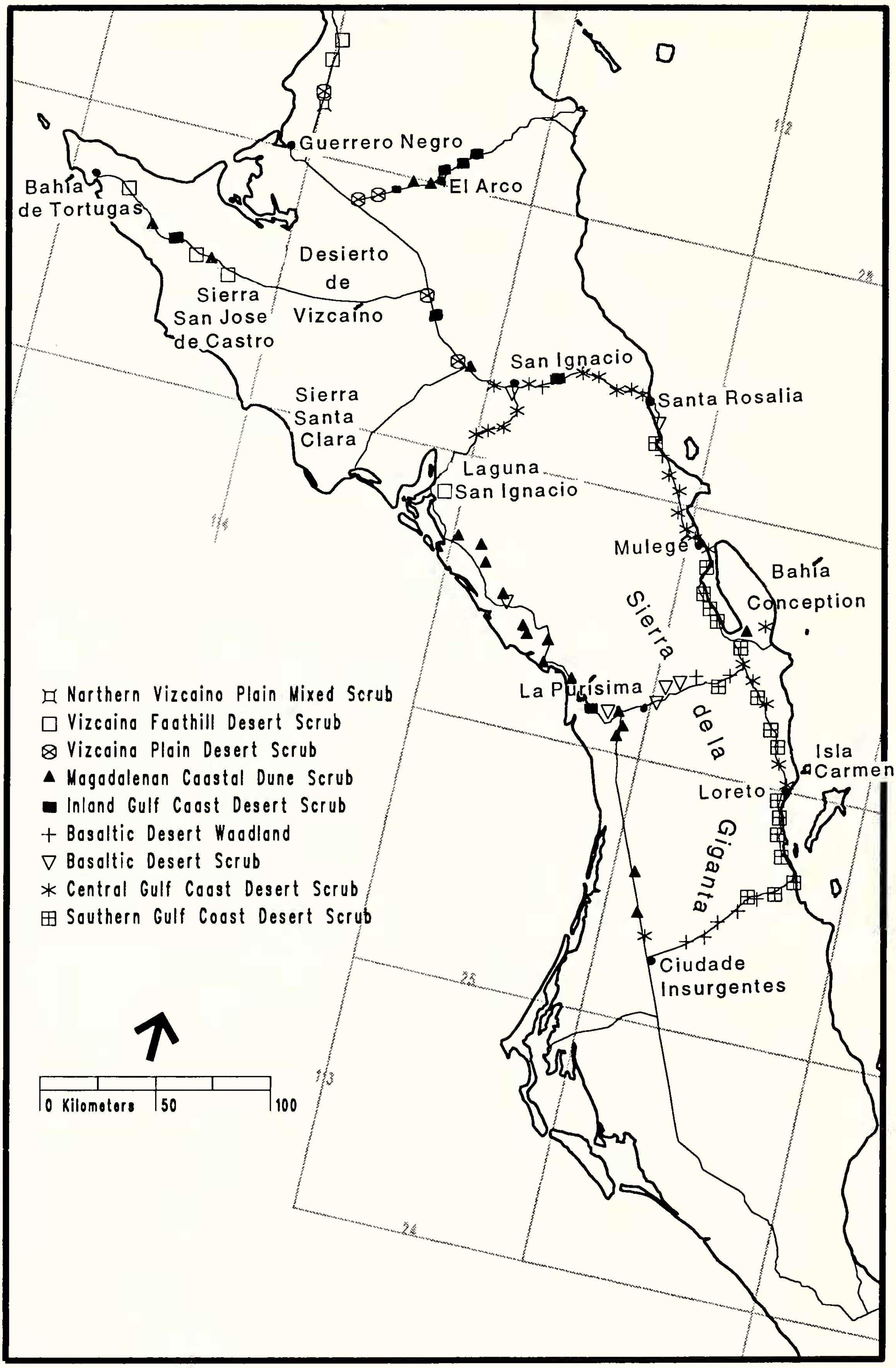


FIG. 3. Transect locations and vegetation types for Baja California Sur. Names of places and topographical features mentioned in the text are also given.

TABLE 1. COMPARISON AMONG VEGETATION TYPES. Values are similarity indices calculated from the equation (2C/A + B)•100, where C is the number of species in common to both vegetation types and A and B are the total number of species present in each type, respectively (Sørensen 1948). Values are slight overestimates of similarity because 21 genera representing plants not identified to the species level were also used (e.g., *Lycium* sp.)

	DCSS	MCSS	CVMS	SCBS	VPDS	RCMS	NVPMS	VFDS	IGCDS	MCDS	BDS	BDW	CGCDS
MCSS	63.5												
CVMS	17.9	45.4											
SCBS	31.5	40.4	66.7										
VPDS	12.2	25.6	39.2	41.5									
RCMS	41.0	58.2	34.7	28.9	38.6								
NVPMS	17.3	28.6	50.0	37.0	47.3	32.1							
VFDS	7.1	22.5	38.4	35.7	55.2	30.5	49.1						
IGCDS	10.4	19.8	40.0	40.0	42.7	22.2	38.6	52.8					
MCDS	23.8	26.7	50.0	51.4	45.8	28.6	41.5	56.5	67.2				
BDS	10.9	20.4	28.0	26.1	39.4	23.9	33.8	35.3	40.4	40.9			
BDW	8.2	15.0	30.4	37.1	33.8	16.7	22.9	30.1	51.9	53.6	61.7		
CGCDS	15.5	21.4	45.8	48.3	48.9	19.8	36.0	28.3	68.3	59.8	23.0	59.8	
SGCDS	11.0	11.4	35.5	31.2	33.7	11.9	17.1	25.9	46.6	45.4	38.7	61.2	59.8

and 29°N in a mosaic distribution. Species composition and total dominance of these two vegetation types are very similar. Their distinction lies mainly in species abundance (Appendix 1). CVMS is dominated more by small shrubs. SCBS includes the region around Cataviña, in which large granitic boulders are abundant. Unique indicator species for SCBS include *Ambrosia magdalenae, A. dumosa,* and *Opuntia echinocarpa.* Also noteworthy is that the conspicuous large spiny shrub, *Fouquieria diguetii,* is present in CVMS and not in SCBS.

Several low mountain ranges within the Vizcaíno Desert, including the Sierra Santa Clara, the Sierra Morro Hermosa, and the Sierra San Jose de Castro, form the only major topographic relief of the area and harbor distinct vegetation types from the surrounding sea of very low scrub (not sampled). Vizcaíno Plain desert scrub (VPDS) is found in the low-lying areas along Highway 1 with fine sandy soil and scattered small dunes. This vegetation type is most closely allied with the Sonoran Desert scrub communities to the north (CVMS, SCBS) due to the dominance of *Larrea tridentata* and *Stenocereus gummosus.* Distinction in the field, however, is based on the presence of *Encelia halimifolium,* which has the highest dominance in that vegetation type. Vizcaíno foothill desert scrub (VFDS) is found north of Guerrero Negro at slightly higher elevations (>50 m) in more mixed soil types and on the Vizcaíno peninsula in the foothills of the Sierra Morro Hermoso and the Sierra El Placer. A single location is also found just south of Laguna San Ignacio along the coast. *Bursera microphylla,* one of the dominant species, is most common on the peninsular mountains, while the *Agave shawii* ssp. *goldmaniana* is most common north of the Guerrero Negro. VFDS has the lowest dominance of any of the communities in this analysis (23.1%). Also aligned closely with VFDS is Northern Vizcaíno Plain mixed scrub (NVPMS), which is found in the vicinity of Rosarito and north of Guerrero Negro. It can be distinguished from VFDS by the presence of *Ambrosia chenopodiifolia* and *Frankenia palmeri,* and the absence of *Atriplex julacea.* This vegetation type is closely allied compositionally, but not geographically, with RCMS due to the sharing of several dominant widespread small shrubs (e.g., *Ambrosia chenopodiifolia, Euphorbia misera,* and *F. palmeri*). Due to the relatively small sample sizes for these three types (Fig. 1), their complete distribution within the Vizcaíno Plain is unknown. Tree and shrub species richness reach their lowest point for the study area in the Vizcaíno Desert.

The six remaining communities are largely restricted to the Magdalena Plain and gulf coast regions south of 28°N and are compositionally closely allied. The two northernmost of these communities, Inland Gulf coast desert scrub (IGCDS) and Magdalenan coastal dune scrub (MCDS) are distinguished from the other four primarily by the rarity or complete absence of *Jatropha cuneata,* a drought-deciduous shrub that becomes very abundant south of 27.5°N. IGCDS is generally found in the Vizcaíno Plain eastern foothills and inland gulf valleys, both with sandy soils. MCDS is found mostly in the sandy soils along the Pacific coast southeast of Laguna San Ignacio. This vegetation type occupies the narrow (about 10 km) fringe between the coast and the mesas to the east. In addition, several locations were found to the north: two in the Vizcaíno peninsular foothills, two in the El Arco region and one near Bahía de los Ángeles. The far northern sample lacks any small shrub cover and may represent an anomaly. However, the other three samples clearly represent communities closely allied with the Pacific coast communities.

The four remaining vegetation types are all characterized by the abundance of one species, *J. cuneata,* which is the most dominant in three of the four communities (and second in the fourth). Large legume trees such as *Cercidium microphyllum, C. praecox, Prosopis palmeri,* and *Lysiloma candida* become common. Total plant cover increases to values seen in the Californian region (40–50%). Central Gulf coast desert scrub (CGCDS) and Southern Gulf coast desert scrub (SGCDS) are found generally in the coastal outwash plains (bajadas) of the Sierra de la Giganta along the Gulf coast. The former is also found inland west of Santa Rosalía. SGCDS is dominated primarily by *J. cuneata* but has sixteen species with dominance values of 1% or greater. *Lysiloma candida* is common in this vegetation type, especially in drainages, and helps differentiate the southern GCDS from the central GCDS.

The last two communities are found primarily in the higher elevations (up to 350 m) in basaltically-derived soils, sometimes amidst large basaltic boulders. Basaltic desert scrub (BDS) is found at least between Highway One and La Purísima with some additional samples west of Santa Rosalía. Basaltic desert woodland (BDW) farther south is characterized by the dominant presence of *P. palmeri* (15.2%), covering almost twice the area of *J. cuneata* in BDW or BDS, hence the term "woodland." This vegetation type is found primarily in the western foothills of the Sierra de la Giganta northeast of Ciudad Insurgentes, with some samples scattered farther north.

Mexican vegetation classification. The results of the subjective classification based on the INEGI vegetation types done prior to the computer analysis are compared with the results of this study in a similarity matrix (Table 2). In northwest Baja California, the INEGI vegetation types are more general than those presented here. DCSS appears to fit well within the bounds of one INEGI vegetation type, *chaparral-vegetación secudaria arbustiva. Matorral rosetófilo costero* overlaps with two vegetation types, MCSS and RCMS. These are

TABLE 2. COMPARISON BETWEEN OUR CLASSIFICATION, BASED ON SPECIES PRESENCE/ABSENCE, AND THE MEXICAN CLASSIFICATON, BASED ON DOMINANT LIFE FORMS. Similarity coefficients are calculated in the same way as in Table 1. Mat. = Matorral; Veg. = Vegetación.

Classification—this study	Classification—Mexican scheme											
	Mat. rosetófilo costero	Chaparral-veg. secudaria arbustiva	Veg. halófila	Mat. desértico rosetófilo	Mat. sarco-crasicaule	Mat. desértico micrófilo	Veg. de desiertos arenosos	Mat. sarco-crasicaule de neblina	Mezquital	Mat. sarcocaule	Mat. sarco-caule-Cardonal	Mat. sarco-caule-subinerme
DCSS	12	91	0	0	0	0	0	0	0	0	0	0
MCSS	75	0	0	0	0	0	0	0	0	0	0	0
RCMS	38	0	0	0	0	0	0	0	0	0	0	0
CVMS	6	0	0	25	65	0	0	0	0	0	0	0
SCBS	0	0	0	26	26	59	0	0	0	0	0	0
VPDS	0	0	0	0	0	25	22	0	0	0	5	0
NVPMS	0	0	0	0	24	0	25	0	0	0	0	0
VFDS	0	0	17	0	7	0	36	0	0	42	0	0
CGCDS	0	0	0	0	0	0	0	6	0	0	25	57
SGCDS	0	0	0	0	0	0	0	0	27	0	24	33
MCDS	0	0	30	0	0	10	0	40	0	15	19	11
IGCDS	0	0	0	0	0	14	0	11	0	24	19	7
BDS	0	0	0	0	0	0	0	0	0	0	15	22
BDW	0	0	0	0	0	0	0	0	29	0	29	7

the only close equivalents in terms of species presence. The other vegetation types presented here resemble portions of two to five other INEGI communities. Most vegetation types share few or no species with those of the Mexican classification.

Discussion

Californian region. Westman (1983) identified three plant communities in north coastal Baja California (Table 3) using an analysis very similar to that presented here. Diegan coastal sage scrub is the southernmost coastal sage scrub association along the Pacific coast of North America and is dominated by mesophyllous, seasonally dimorphic and drought-deciduous species. It also has the highest species richness per sample area of all of the coastal central and southern Californian region scrub communities (Westman 1983). Results from this study generally support these two classifications of Westman (1983), including their geographical extent. However, quantitative results differ. For DCSS, our analysis revealed a strong dominance by *Viguiera laciniata,* only encountered rarely by Westman. The reason for this is likely Westman's small sample size (n = 3) in this vegetation type. The dominant and uncommon species listed for the Martirian coastal succulent scrub community by Westman differed significantly from our results. The two most dominant species in our analysis were listed in Westman (1983) as present in only a minority of samples. In addition, his dominants have relatively low dominance in our study. This may indicate that, while this vegetation type is easily distinguishable from surrounding types, it is very heterogeneous in species composition on a local scale. We found that several species (many of which are listed as rare or endangered in the United States) were much more common across the border in the Diegan coastal sage scrub that we surveyed. These included *Rosa minutifolia, Salvia munzii,* and *Euphorbia misera.* However, while these species were sometimes dominants, they were absent from many of our samples. Thus, our results support those of Westman (1983), who did not make a distinction between vegetation types across the border.

The boundary between the Californian region and the Sonoran Desert cannot be drawn by a single line on a map due to the transitional nature (ecotone) of the vegetation in this region (Shreve 1951; Turner and Brown 1982; Wiggins 1980). El Rosario has traditionally been the cutoff between the two major floristic regions and floristic support for this division is not lacking. Many important components of the Sonoran Desert reach their northwestern limits at or near El Rosario, including *Fouquieria splendens, Idria columnaris, Larrea tridentata,* and *Agave cerulata* (Shreve 1951; Hastings et al. 1972; Gentry 1978). However, there are many other species

TABLE 3. A COMPARISON OF VEGETATION TYPES BETWEEN THIS AND PREVIOUS STUDIES ON BAJA CALIFORNIA.

This study	Shreve (1951) and Wiggins (1980)	Turner and Brown (1982)	Westman (1983)
Diegan coastal sage scrub	Californian Region		Diegan coastal sage scrub
Martirian coastal succulent scrub			Martirian coastal succulent scrub
Central Vizcainan mixed scrub	Sarcophyllous Desert (in part)	Vizcaino Subdivision (in part)	
Sonoran creosote-bursage scrub			
Vizcaino Plain desert scrub			
Rosarian coastal mixed scrub		Maguey-Boojum Series	Vizcainan coastal succulent scrub
Northern Vizcaino Plain mixed scrub		Frankenia-Ocotillo-Datilillo Series	
Vizcainan foothill desert scrub			
Inland Gulf coast desert scrub	Sarcocaulescent Desert (in part)	Central Gulf Coast Subdivision (in part)	
Central Gulf coast desert scrub		Torchwood-Cardon Series	
Southern Gulf coast desert scrub			
Magdalenan coastal dune scrub	Magdalenan Region (in part)	Magdalena Plain Subdivision (in part)	
Basaltic desert woodland	Sierra de la Giganta Region (in part)	Cape Region (in part)	
Basaltic desert scrub			

whose range overlaps the two regions significantly. More conspicuous ones include *Eriogonum fasciculatum, Simmondsia chinensis, V. laciniata, Euphorbia misera, Agave shawii* ssp. *shawii,* and *Ambrosia chenopodifolia* (Shreve 1951; Hastings et al. 1972; Gentry 1978).

Westman (1983) identifies a scrub community surrounding El Rosario that is distinct from the Martirian community to the north, termed Vizcainan coastal succulent scrub. He groups this association within the Californian region, although he acknowledges the possibility of a closer affinity with the Sonoran Desert. Our results confirm Westman's speculations of an affinity (albeit weak) of this association with the vegetation of the Sonoran desert, renamed Rosarian coastal mixed scrub (RCMS) in order to distinguish this from the Vizcaíno desert plant communities farther south. Figure 4 shows our slightly modified boundaries of the Californian region, as well as other modifications of the major Sonoran desert subdivision discussed later. The ultimate fate of RCMS is largely moot as it clearly represents a broad ecotone between the Sonoran desert and Californian region. It is worth noting the inclusion by Westman (1983) of *Amblyopappus pusillus* (Asteraceae), a spring-blooming annual, as the dominant species of this vegetation type. Our study did not correspond to the flowering time of this species. However, it is surprising that one annual species could so dominate the landscape of this area, which Westman states is characterized by relatively high shrub dominance (41.65%) and diversity. Our sample size within this region is only n = 6, as is Westman's (1983). This may account for some of the discrepancies in species composition.

Sonoran Desert. In the seminal work on Sonoran Desert flora, Shreve (1951) identified seven distinct floristic regions, four of which occur in Baja California. These divisions were made based solely on qualitative vegetation characteristics, although they generally correspond to physiographic and climatic regions as well (Shreve 1951; Turner and Brown 1982). This general mapping was later modified by Brown and Lowe (1980) and included in Turner and Brown (1982). The TWINSPAN classification presented here gives a large-scale pattern of Sonoran Desert plant communities generally similar to that proposed by Shreve (1951), with several notable deviations discussed below.

The microphyllous desert (syn. Lower Colorado River Valley subdivision) extends into the region of this survey only at its southern tip in a narrow band along the gulf coast as far south as Bahía de los Ángeles. Sonoran creosote-bursage scrub (SCBS) is the only vegetation type described here that would fit well in this category, with its dominance by *Larrea tridentata* and *Ambrosia* spp. However, comparison with qualitative descriptions (Shreve 1951; Turner and

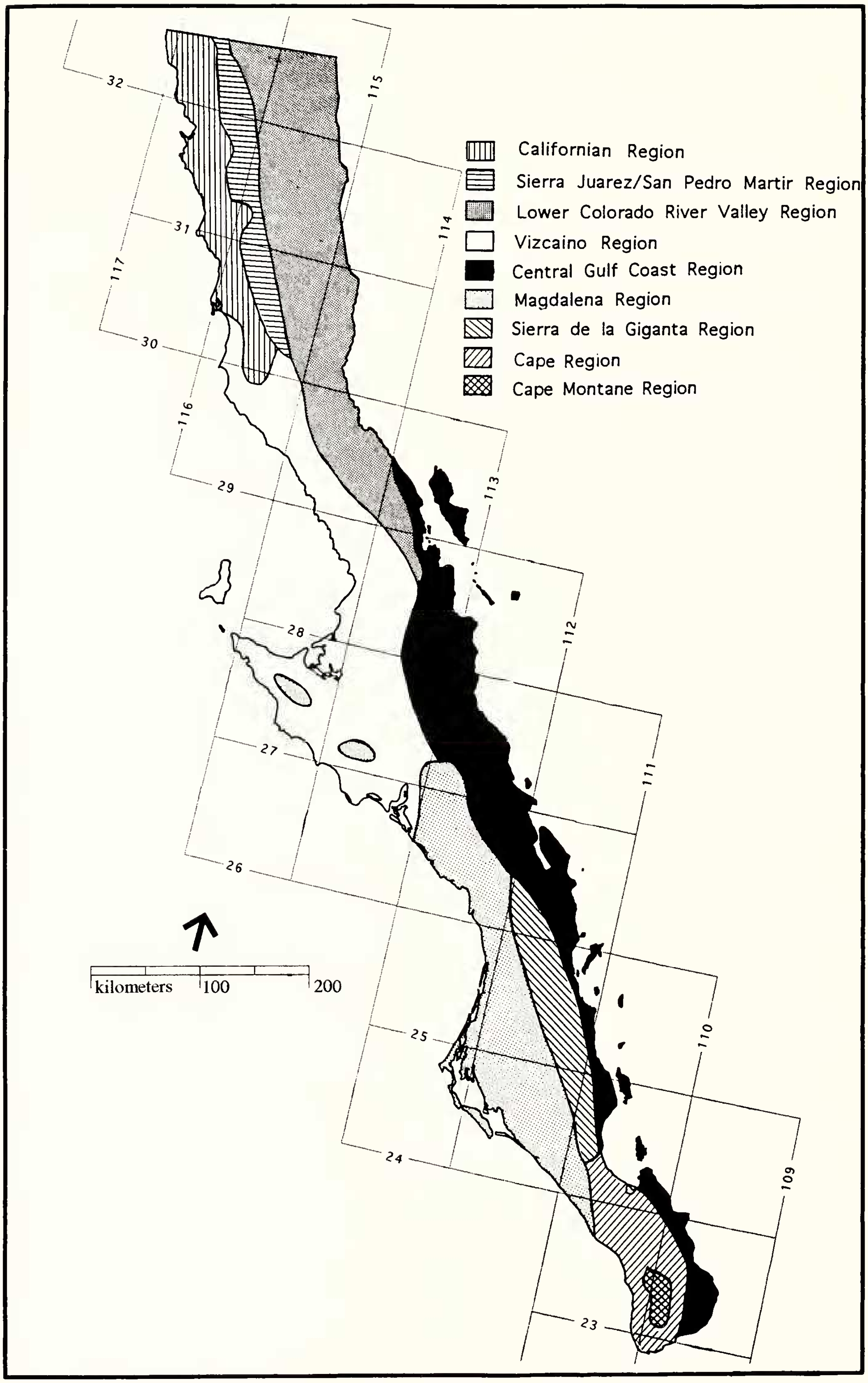


Fig. 4. Baja California general plant community distribution (modified from Wiggins 1980 and Turner and Brown 1983).

Brown 1982) shows a much higher shrub diversity present in SCBS. The southern end of this subdivision is not well described, so a detailed comparison is not possible. According to this analysis, the southern limits of this subdivision could be moved farther inland than currently recognized, to encompass more of the central highlands surrounding Highway One. Closely allied samples cross the boundaries of the remaining three divisions, sarcophyllous desert (syn. Vizcaíno subdivision), sarcocaulescent desert (syn. Central Gulf Coast subdivision) and Magdalenan, although the majority are restricted to the individual regions.

Our analysis reveals a complex pattern of vegetation in the Vizcaíno Desert mountains (the Sierra Santa Clara is mapped as a similar complex mosaic of Sonoran Desert vegetation types by Leon de la Luz 1991). This may be due in part to their isolation from the more inland mountains. In addition, however, mean summer temperatures are at least 5°C lower than that of other Sonoran Desert regions, largely due to the coastal fog influence of the Pacific Ocean (Turner and Brown 1982). The vegetation of the flat desert plain is primarily composed of two vegetation types, neither of which were sampled in this study. The first is dominated by very low (<0.5 m) shrubs of mostly *Frankenia palmeri* and *Atriplex* spp., especially *A. julacea* (Turner and Brown 1982; Leon de la luz et al. 1991). The second is found on stabilized and unstabilized dune fields throughout the peninsula. Vegetation in these areas is composed of a wider diversity of life forms (shrubs include *Larrea tridentata, Lycium californicum, Errazurizia megacarpa* and *Atriplex barclayana*), although it is still relatively species-depauperate (Leon de la Luz et al. 1991).

The sarcocaulescent desert is described for Baja California along the Gulf coast in a coastal strip about 40 km wide from 29.5°N to almost the tip of the peninsula. Turner and Brown (1982) add to Shreve's description that "There is a general absence of a low shrub cover layer. . . ." Our data do not support this statement, at least on the Baja peninsula region of this subdivision (it extends along a similar coastal region in Sonora); shrub cover along the coast (CGCDS and SGCDS) is comparable to that of other Sonoran desert communities (15–25% cover). Average annual rainfall in this subdivision varies widely, from 71 mm in the north (Bahía de los Ángeles), to 270 mm in the south (Turner and Brown 1982), with a mean of 134.8 mm (SD = 55.2). Turner and Brown analyzed rainfall data from Baja California and Sonora within this subdivision and found only a weak correlation between latitude and rainfall amount. We analyzed rainfall data from only the Baja California side of the Sea of Cortez (n = 12) and found a strong correlation with latitude (corr. coeff. = −0.769); no correlation exists between elevation and rainfall patterns. This gradual increase in rainfall as one moves south along the Gulf coast would suggest an equally gradual transition in vegetation along the same area. This is supported at least as far as 25.5°N latitude. Central Gulf coast desert scrub gives way to Southern Gulf coast desert scrub farther south. Moreover, there is a clear trend towards greater tree cover moving south along the entire study route.

It appears that IGCDS is a transitional vegetation between the sarcocaulescent desert and the Magdalenan region, and could actually be placed in either (although the TWINSPAN analysis allies this vegetation type with MCDS). If it is placed in the former subdivision as is proposed here (Fig. 4), the boundaries of the sarcocaulescent desert would be moved farther inland to at least the vicinity of El Arco (28°N, 113.5°W).

Turner and Brown (1982) built on the general classification scheme of Shreve (1951), classifying many localized plant communities (termed "series"; Table 1). Within these series, visual dominants were qualitatively identified. They performed a intensive quantitative survey near Punta Prieta using thirty 30.5 m long line transects (R. Turner personal communication 1991), describing the localized agave-boojum series. Because the samples of this and of our study were taken on different scales, comparison is unwarranted. However, it is worth noting that *Fagonia californica* had the highest density recorded for any species in their samples, but a very low dominance (0.74%; relative dominance = 0.03%) (Turner and Brown 1982). An effort was made to locate this species, a prostate-spreading perennial herb (Zygophyllaceae), in this vicinity during our survey, but very few individuals were found. *Eriogonum fasciculatum* was present in the Punta Prieta area in abundance, yet none were recorded in the transects of Turner and Brown (1982). This may represent a change in vegetation patterns between the times of the two surveys.

Turner and Brown (1982) also sampled the Cataviña area quantitatively and described the Ragged-leaf goldeneye–boojum series, a localized community associated with distinctive abundant granitic outcrops. Our analysis failed to separate this localized vegetation type, even at more detailed TWINSPAN classifications (past those described here). This could possibly be due to our small sample size in this vegetation type (n = 5). However, it is more likely that the species composition around Cataviña is not significantly distinct from the adjacent regions and does not merit a separate vegetation type based on composition alone.

Scant attention has been paid to the Pacific coastal region between San Ignacio and the Cape region by phytogeographers, and although boundaries have been drawn by various workers (Shreve 1951; Shreve and Wiggins 1964; Turner and Brown 1982), a detailed description is lacking. This study describes one vegetation type within the northern portion of this region, Magdalenan coastal dune scrub, of which three samples extend beyond its recognized northern boundaries.

This may further illustrate the very gradual transitions of vegetation patterns seen throughout Baja California.

Subtropical Cape region. In Shreve (1951) and most other subsequent treatments of Baja California Sonoran Desert vegetation, the boundary between the subtropical Cape region and the Sonoran Desert traces a triangle approximately between Comondú, La Paz and Todos Santos. Thus the Cape region is usually defined as below 24°N except for a 20 kilometer-wide belt stretching northwest up to 26.5°N, essentially encompassing the Sierra de la Giganta range up to Bahía Concepción. This boundary dates back to at least 1911 (see refs in Shreve and Wiggins [1964], p. 10). In contrast, our analysis shows little compositional difference between the two communities (BDS and BDW) occurring within Shreve's subtropical Cape region and those within the Sonoran Desert proper. Another worker has noted similar discrepancies (Leon de la Luz personal communication 1991). These boundaries, according to Shreve, were defined purely on the basis of vegetation and flora: "The vegetation of the Sonoran desert is distinguished from that of adjacent regions by the wide differences in appearance between dominant plants" (Shreve and Wiggins 1964, p. 39). Even though BDW has a much higher cover of thorny trees than any other vegetation type (over 20%), Shreve's statement leads one to expect greater compositional differences. However, there were relatively few samples in this area and no comparison was made with regions farther south that are clearly part of the Cape region. Wiggins (1980) proposed two general regions within the subtropical Cape Region, the Sierra de la Giganta Region and the Arid Tropical Region. Our analysis would support this boundary between the vegetation of the northern finger of the subtropical region and the very distinct vegetation of the Cape. However, the question of whether the vegetation of the Sierra de la Giganta would be considered part of the Sonoran Desert remains unanswered.

Mexican vegetation classification and mapping. There are advantages to using a life-form classification scheme in relatively open, desert habitats. For one, aerial photography can be used to map large areas using this classification method (Goldsmith 1974). In addition, this method can be useful for large-scale comparisons both within a region and across ecosystems (Kent and Coker 1992). However, the almost completely subjective nature of life-form classification often raises questions about the repeatability of the methods. Those unfamiliar with the vegetation of the region may find such a classification difficult to interpret in the field (Kent and Coker 1992). Classification based on floristic data is also appropriate for desert ecosystems due to the relative ease in identification of the perennial component of the vegetation. Baja California is unique among Mexican regions in that an excellent flora is available (Wiggins 1980), thus allowing a detailed, repeatable classification method such as that presented here.

There are sixteen vegetation types listed on the Mexican maps for the region within this survey. Many are further split into several associations and a list of dominant and conspicuous species within variable strata categories is included with almost every map. Classification was based on the dominant life form of a given area and was determined by subjective visual analysis (Vargas-Medoza personal communication 1991) using aerial photography and field verification (INEGI 1980–1988) in conjunction with the previous work of Miranda and Hernandez X. (1968) and Rzedowski (1978). However, the classification method is not explicitly defined and we were unable to find a published account of the methods.

Given the different goals of the two classification methods, it is not surprising that the comparison of vegetation types (Table 2) showed little similarity. Most vegetation types appear to share no common species. This is partially due to the short list of species given for the Mexican types. Because this list includes both dominants (as defined in this paper) and visually conspicuous species, we could not limit our list of species in a similar manner. While DCSS appears to fit within the bounds of one INEGI vegetation type, *chaparral–vegetación secudaria arbustiva,* it extends far beyond the elevational range of Diegan coastal sage scrub and probably includes other commonly recognized scrub communities such as those dominated by *Artemisia tridentata* or *Arctostaphylos* spp. (D. Zippin personal observation).

There are several major inconsistencies between the 1:1,000,000 scale and 1:250,000 scale Mexican vegetation maps, particularly for chaparral, *vegetación halófilo,* and *vegetación sarcocaule.* While qualitative descriptions are given for dozens of localized plant communities, few are mapped at either of the 1:1,000,000 and 1:250,000 scales. A revision of the 1:1,000,000 scale map has been completed for the Vizcaíno Biosphere Reserve (located between 28°N and 26.5°N from coast to coast, including the entire Vizcaíno Desert; Leon de la Luz et al. 1991). This revision has corrected much of the inaccuracy in the *vegetación halófilo* community. However, many inconsistencies between the two maps remain, which call into question the accuracy of the 1:250,000 scale maps. In regions most similar in vegetation to that of the United States, we found the use of these maps particularly difficult. Mapping units were clearly defined quite differently from those across the border. Efforts are currently underway to standardize vegetation sampling and classification across California. If international cooperation in vegetation management and protection is to occur, compatible definitions must be agreed upon for the vegetation types that our counties share. In conclusion, the Mexican classification does not correspond well to the vegetation classification presented in this study. The life form classification scheme used in these maps may be useful to vegetation scientists in some instances. However, the mapping of these life form associations should be used only as a general guide, perhaps only at the 1:1,000,000 scale.

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Appendix 1. Dominance Values for Plant Communities. Species are grouped according to their closest vegetation affinities (i.e., associations within and among sample stands). General life forms: C = columnar succulent; S = succulent; Sb = subshrub; Sh = shrub; T = tree. Plant community types: DCSS = Diegan coastal sage scrub; MCSS = Sonoran creosote–bursage scrub; VPDS = Vizcaino Plain desert scrub; RCMS = Rosarian coastal mixed scrub; NVPMS = Northern Vizcaino Plain mixed scrub; VFDS = Vizcaino foothill desert scrub; IGCDS = Inland Gulf Coast desert scrub; MCDS = Magdalenan coastal dune scrub; BDS = Basaltic desert scrub; BDW = Basaltic desert woodland; CGCDS = Central Gulf Coast desert scrub; SGCDS = Southern Gulf Coast desert scrub. P = species present in vegetation type but not recorded by line transect.

Species	Family	General life form	Plant community		
			DCSS	MCSS	CVMS
Ambrosia camphorata	Asteraceae	Sb	—	—	0.40
Aeschynomene nivea	Fabaceae	Sh	—	—	—
Berginia virgata var. *glandulifera*	Acanthaceae	Sh	—	—	—
Bourreria sonorae	Boraginaceae	Sh	—	—	—
Bursera epinnata	Burseraceae	T	—	—	—
Caesalpinia placida	Fabaceae	Sh	—	—	—
Castela polyandra	Simaroubaceae	Sh	—	—	—
Cercidium microphyllum	Fabaceae	T	—	—	—
Cochemia poselgeri	Cactaceae	S	—	—	—
Colubrina viridis	Rhamnaceae	Sh	—	—	—
Cordia parvifolia	Boraginaceae	Sh	—	—	—
Euphorbia sp.	Euphorbiaceae	Sh	—	—	—
Hoffmanseggia intricata	Fabaceae	Sh	—	—	—
Hyptis anitae	Lamiaceae	Sh	—	—	—
Krameria paucifolia	Krameriaceae	Sh	—	—	—
Lysiloma candida	Fabaceae	T	—	—	—
Olneya tesota	Fabaceae	T	—	—	—
Passiflora foetida var. *longipedunculata*	Passifloraceae	Sh	—	—	—
Pithecellobium confine	Fabaceae	Sh	—	—	—
Ruellia californica	Acanthaceae	Sh	—	—	—
Bursera microphylla	Burseraceae	T	—	—	0.40
Jatropha cuneata	Euphorbiaceae	Sh	—	—	—
Bursera odorata	Burseraceae	T	—	—	—
Krameria parvifolia var. *parvifolia*	Krameriaceae	Sh	—	—	—
Stenocereus thruberi	Cactaceae	S	—	—	—
Acacia brandegeana	Fabaceae	T	—	—	—
Agave aurea	Agavaceae	S	—	—	—
Bursera cerasifolia	Burseraceae	T	—	—	—
Bursera filifolia	Burseraceae	T	—	—	—
Cercidium praecox	Fabaceae	T	—	—	—
Desmanthus covellei	Fabaceae	Sh	—	—	—
Echinocereus brandeegei	Cactaceae	S	—	—	—
Prosopis palmeri	Fabaceae	T	—	—	—
Ruellia cordata	Acanthaceae	Sh	—	—	—
Ruellia peninsularis	Acanthaceae	Sh	—	—	—

APPENDIX 1. EXTENDED.

Plant community										
SCBS	VPDS	RCMS	NVPMS	VFDS	IGCDS	MCDS	BDS	BDW	CGCDS	SGCDS
0.13	—	—	—	—	—	—	4.81	1.38	P	—
—	—	—	—	—	—	—	—	—	P	0.64
—	—	—	—	—	—	—	—	P	—	0.62
—	—	—	—	—	—	—	—	—	—	0.07
—	—	—	—	—	P	—	—	—	0.20	0.79
—	—	—	—	—	P	—	—	—	0.07	1.52
P	—	—	—	—	—	—	—	—	P	—
—	—	—	—	—	0.30	P	—	P	1.13	2.62
—	—	—	—	—	—	—	—	P	0.18	P
—	—	—	—	—	P	—	—	0.93	0.25	2.13
—	—	—	—	—	—	—	—	0.29	0.88	1.79
—	—	—	—	—	—	—	—	—	P	—
—	—	—	—	—	—	—	—	—	—	0.24
—	—	—	—	—	—	—	—	—	—	0.80
—	—	—	—	—	—	—	0.99	—	0.17	0.70
—	—	—	—	—	—	—	P	P	P	2.54
P	—	—	—	—	P	P	—	0.08	P	1.77
—	—	—	—	—	—	—	—	—	—	P
—	—	—	—	—	—	—	—	—	0.49	—
—	—	—	—	—	—	—	—	0.66	0.14	2.97
P	—	—	4.89	2.15	1.70	1.20	1.45	0.85	6.07	4.13
—	—	—	—	—	1.32	P	9.04	9.24	11.52	9.28
—	—	—	—	—	—	—	—	P	—	P
—	P	—	—	—	—	—	0.91	P	0.30	P
—	—	—	—	—	0.21	P	0.11	0.55	0.16	1.49
—	—	—	—	—	—	—	2.61	—	—	—
—	—	—	—	—	—	—	P	—	—	—
—	—	—	—	—	—	—	—	P	—	—
—	—	—	—	—	—	—	P	—	—	—
—	—	—	—	—	—	—	2.87	6.29	—	0.36
—	—	—	—	—	—	—	1.51	P	—	—
—	—	—	—	P	0.26	0.09	1.27	0.19	0.18	—
—	—	—	—	—	—	—	P	15.17	—	—
—	—	—	—	—	—	—	0.33	—	—	—
—	—	—	—	—	P	—	P	1.56	—	3.52

APPENDIX 1. CONTINUED.

Species	Family	General life form	Plant community DCSS	MCSS	CVMS
Bursera hindsiana	Burseraceae	T	—	—	—
Agave sp.	Agavaceae	S	—	—	—
Ambrosia bryantii	Asteraceae	Sh	—	—	—
Ferocactus diguetii	Cactaceae	S	—	—	0.18
Fouquieria diguetii	Fouquieriaceae	Sh	—	—	0.40
Opuntia ciribe	Cactaceae	S	—	—	—
Cercidium sp.	Fabaceae	T	—	—	—
Echinocereus engelmannii	Cactaceae	S	—	—	—
Ephedra sp.	Ephedraceae	Sh	—	—	—
Jatropha cinerea	Euphorbiaceae	Sh	—	—	P
Sapium biloculare	Euphorbiaceae	Sh	—	—	—
Ephedra trifurca	Ephedraceae	Sh	—	P	—
Euphorbia magdalenae	Euphorbiaceae	Sh	—	—	—
Fagonia californica	Zygophyllaceae	Sb	—	—	P
Hyptis sp.	Lamiaceae	Sh	—	—	—
Lippia palmeri	Verbenaceae	Sb	—	—	—
Lycium bierlandei	Solanaceae	Sh	—	—	—
Lycium californicum	Solanaceae	Sh	—	—	1.29
Opuntia sp.	Cactaceae	S	—	—	—
Opuntia tapona	Cactaceae	S	—	—	—
Phaulothamnus spinescens	Phytolaccaceae	Sh	—	—	—
Ruellia sp.	Acanthaceae	Sh	—	—	—
Trixis angustifolia	Asteraceae	Sh	—	—	—
Viguiera deltoidea	Asteraceae	Sh	—	—	—
Asclepias masonii	Asclepiadaceae	Sh	—	—	—
Condalia globosa	Rhamnaceae	Sh	—	—	—
Jacquemontia abutiloides	Convolvulaceae	Sb	—	—	—
Maytenus phyllanthoides	Celastraceae	Sh	—	—	—
Suaeda sp.	Chenopodiaceae	Sb	—	—	—
Opuntia cholla	Cactaeae	S	0.07	0.31	1.96
Prosopis sp.	Fabaceae	T	P	—	0.29
Ambrosia deltoides	Asteraceae	Sh	—	—	—
Euphorbia californica	Euphorbiaceae	Sh	—	—	0.50
Euphorbia xantii	Euphorbiaceae	Sh	—	—	P
Pedilanthus macrocarpus	Euphorbiaceae	Sh	—	—	0.07
Bebbia juncea	Asteraceae	Sh	—	—	—
Euphorbia tomentulosum	Euphorbiaceae	Sh	—	—	P
Lophocereus schottii	Cactaceae	C	0.85	—	0.69
Pachycereus pringlei	Cactaceae	C	—	P	0.40
Solanum hindsianum	Solanaceae	Sh	—	—	P
Ambrosia magdalenae	Asteraceae	Sh	—	—	—
Calliandra californica	Fabaceae	Sh	—	—	—
Hymenoclea sp.	Asteraceae	Sh	—	—	—
Lycium sp.	Solanaceae	Sh	0.22	0.51	1.56
Viguiera microphylla	Asteraceae	Sh	—	—	—
Larrea tridentata	Zygophyllaceae	Sh	—	—	2.06
Ditaxis lanceolata	Euphorbiaceae	Sb	—	—	—
Encelia farinosa	Asteraceae	Sh	—	—	—
Prosopis articulata	Fabaceae	T	—	—	0.12

Appendix 1. Extended. Continued.

Plant community										
SCBS	VPDS	RCMS	NVPMS	VFDS	IGCDS	MCDS	BDS	BDW	CGCDS	SGCDS
—	—	—	—	P	1.08	P	—	P	0.18	0.62
—	—	—	—	—	0.40	—	P	—	—	—
—	—	—	—	0.63	1.06	0.12	6.63	1.24	P	—
0.11	—	—	—	—	—	—	—	—	—	—
—	0.48	—	1.29	3.54	6.11	2.35	6.69	2.39	6.92	3.55
—	1.55	—	—	—	—	1.12	1.05	0.04	0.40	P
—	—	—	—	—	—	P	—	—	—	—
—	—	—	—	—	—	—	0.25	0.29	0.21	P
0.76	—	0.79	—	—	—	P	—	—	—	—
P	1.03	—	—	P	3.89	1.03	P	0.79	1.00	2.40
—	—	—	—	—	P	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	P
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	P
—	—	—	—	—	0.15	—	—	—	—	P
—	2.69	—	—	—	—	—	—	—	—	—
—	—	—	1.63	—	—	—	—	—	—	P
P	—	P	—	—	P	P	P	—	—	—
—	—	—	—	—	—	—	P	—	—	—
—	—	—	—	—	P	P	—	—	—	—
—	—	—	—	—	0.08	—	—	—	—	—
—	—	—	—	—	P	—	—	—	—	—
—	—	—	—	—	P	P	—	—	—	P
—	—	—	—	—	—	P	—	—	—	—
—	—	—	—	—	0.34	—	—	—	—	—
—	—	—	—	—	—	P	—	—	—	P
—	—	—	—	—	0.25	0.49	—	—	—	—
—	—	—	—	—	0.30	—	—	—	—	—
0.13	1.28	P	P	—	2.31	2.56	1.86	3.11	2.21	2.43
0.14	—	—	—	—	—	—	—	—	0.33	2.34
—	—	—	—	P	0.29	3.13	—	P	0.30	—
P	—	—	—	—	0.09	1.00	—	2.23	0.41	0.67
—	—	—	P	—	0.07	—	P	—	P	P
—	0.58	—	—	—	0.40	0.71	—	0.19	0.36	P
0.08	—	—	—	—	—	—	—	—	—	P
—	—	—	—	—	—	0.38	—	—	—	0.08
0.33	P	P	—	P	—	0.65	—	—	0.23	0.24
0.11	P	P	—	P	0.13	0.16	0.16	0.13	0.02	P
0.78	P	—	P	—	0.15	1.27	P	0.20	P	0.20
1.03	P	—	—	P	P	1.64	—	—	0.25	P
0.11	—	—	—	P	P	—	—	—	P	—
P	—	—	—	—	—	—	—	—	—	—
0.75	1.28	1.88	—	4.43	6.26	1.60	2.83	7.85	1.18	1.82
—	—	—	—	—	P	—	—	—	0.35	—
9.08	5.47	—	0.33	P	2.79	6.07	P	P	4.53	0.53
—	—	—	—	—	—	—	—	—	—	0.10
0.64	—	—	—	—	P	0.32	—	P	P	P
0.20	—	—	—	—	—	—	—	—	—	—

APPENDIX 1. CONTINUED.

Species	Family	General life form	Plant community		
			DCSS	MCSS	CVMS
Viguiera purisimae	Asteraceae	Sh	—	—	—
Errazurizia benthamii	Fabaceae	Sh	—	—	—
Frankenia palmeri	Frankeniaceae	Sh	—	—	—
Encelia halimifolia	Asteraceae	Sh	—	—	0.30
Ferocactus peninsulae	Cactaceae	S	—	—	P
Yucca valida	Agavaceae	S	—	—	0.49
Acacia farnesiana	Fabaceae	T	—	—	—
Acacia greggii	Fabaceae	Sh	—	—	P
Acanthogilia gloriosa	Polemoniaceae	Sh	—	—	P
Ambrosia dumosa	Asteraceae	Sh	—	0.39	0.03
Asclepias albicans	Asclepiadaceae	Sh	—	—	—
Bursera sp.	Burseraceae	T	—	—	P
Dalea spinosa	Fabaceae	Sh	—	—	P
Fouquieria splendens	Fouquieriaceae	Sh	—	—	1.90
Haplopappus sonorensis	Asteraceae	Sh	—	—	—
Krameria grayi	Krameriaceae	Sh	—	—	—
Lycium andersonii	Solanaceae	Sh	—	1.14	—
Lycium exsertum	Solanaceae	Sh	—	—	0.13
Mammilaria sp.	Cactaceae	S	P	0.02	P
Prosopis glandulosa var. *torreyana*	Fabaceae	T	—	—	0.36
Yucca schidigera	Agavaceae	S	—	—	P
Agave cerulata	Agavaceae	S	—	—	0.48
Beloperone californica	Acanthaceae	Sh	—	—	P
Opuntia molesta	Cactaceae	S	—	—	0.71
Opuntia tesajo	Cactaceae	S	—	—	0.20
Vizcainoa geniculata	Zygophyllaceae	Sh	—	—	P
Atriplex barclayana	Chenopodiaceae	Sh	—	—	P
Atriplex julacea	Chenopodiaceae	Sh	—	—	0.38
Encelia sp.	Asteraceae	Sh	—	—	0.25
Haplopappus venetus	Asteraceae	Sh	—	—	—
Pachycormus discolor	Anacardiaceae	T	—	—	1.05
Atriplex sp.	Chenopodiaceae	Sh	—	0.47	0.51
Encelia californica	Asteraceae	Sh	P	0.66	0.71
Idria columnaris	Fouquieriaceae	C	—	0.12	1.08
Atriplex canescens	Chenopodiaceae	Sh	—	P	—
Opuntia acanthocarpa	Cactaceae	S	0.06	—	P
Stenocereus gummosus	Cactaceae	S	—	2.41	0.54
Viguiera triangularis	Asteraceae	Sh	—	0.23	0.67
Ferocactus acanthodes	Cactaceae	S	—	P	P
Ferocactus sp.	Cactaceae	S	—	0.03	—
Agave shawii ssp. *goldmaniana*	Agavaceae	S	—	—	—
Ambrosia divaricata	Asteraceae	Sh	—	—	—
Atriplex polycarpa	Chenopodiaceae	Sh	—	—	0.08
Mirabilis laevis	Nyctaginaceae	Sh	P	0.10	P
Opuntia echinocarpa	Cactaceae	S	P	—	P
Opuntia ramosissima	Cactaceae	S	P	0.19	0.40
Acalypha californica	Euphorbiaceae	Sh	P	P	P

APPENDIX 1. EXTENDED. CONTINUED.

Plant community										
SCBS	VPDS	RCMS	NVPMS	VFDS	IGCDS	MCDS	BDS	BDW	CGCDS	SGCDS
P	—	—	—	—	0.57	0.53	P	P	—	—
—	—	—	—	0.29	—	0.10	—	—	0.21	—
—	P	3.78	6.23	0.41	0.42	P	—	—	0.21	—
0.54	8.49	—	—	0.86	P	0.37	—	—	P	0.05
P	—	—	P	P	P	—	—	—	P	—
0.30	0.83	—	P	0.23	P	P	—	—	P	—
—	—	—	—	—	P	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
2.85	—	—	—	—	—	—	—	—	—	—
P	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	0.30
—	—	—	—	—	—	—	—	—	—	—
1.22	—	—	—	—	—	—	—	—	—	—
—	P	—	—	—	—	—	—	—	—	—
0.17	—	—	—	—	—	—	—	—	—	—
—	—	0.37	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
P	P	0.47	P	—	P	P	P	P	0.01	—
0.35	4.93	—	—	—	—	—	—	—	—	—
P	—	—	—	—	—	—	—	—	—	—
0.66	—	—	—	P	0.13	1.51	—	—	0.18	—
—	—	—	—	—	—	—	—	—	—	P
0.29	—	—	—	—	0.07	1.42	—	0.15	P	—
0.45	—	—	P	—	—	0.16	0.82	0.30	—	—
—	—	—	—	—	P	0.35	—	—	P	—
—	—	—	P	—	—	—	0.45	—	—	—
—	—	—	0.08	2.23	—	—	—	—	P	—
—	P	—	P	0.89	P	0.19	—	—	P	—
—	—	P	—	—	—	—	—	—	—	—
—	—	—	2.54	1.40	P	P	—	—	—	—
0.07	P	2.05	0.17	1.58	1.49	—	—	—	0.05	—
0.03	—	—	—	—	1.35	0.43	—	—	—	—
0.31	—	—	P	P	—	P	—	—	—	—
—	P	—	—	P	0.16	—	0.19	—	P	—
0.19	—	—	—	—	0.30	P	—	0.40	0.54	0.40
P	2.57	0.71	0.77	0.16	4.32	2.57	0.38	1.86	1.57	2.46
—	—	—	—	—	—	—	—	—	P	1.00
0.03	0.22	—	P	P	P	—	—	—	0.04	—
—	P	P	—	P	—	0.27	0.32	—	—	—
—	—	—	3.56	2.41	—	—	—	—	—	—
—	—	—	—	—	0.09	—	—	—	0.05	—
0.51	P	5.92	—	—	—	—	—	—	—	—
—	—	—	—	—	—	P	—	—	—	P
0.04	—	—	—	—	—	—	—	—	—	—
P	—	0.09	—	—	—	—	—	—	—	—
0.52	0.07	—	—	—	—	—	—	—	P	—

APPENDIX 1. CONTINUED.

Species	Family	General life form	Plant community DCSS	MCSS	CVMS
Hyptis tephrodes	Lamiaceae	Sh	—	—	—
Lycium torreyi	Solanaceae	Sh	—	2.47	1.27
Yucca whipplei	Agavaceae	S	P	0.43	P
Ambrosia chenopodiifolia	Asteraceae	Sh	0.47	10.37	7.09
Opuntia prolifera	Cactaceae	S	—	P	P
Agave shawii ssp. *shawii*	Agavaceae	S	P	6.40	1.49
Dudleya edulis	Crassulaceae	S	P	0.05	—
Echinocereus maritimus	Cactaceae	S	—	0.09	—
Echinocereus sp.	Cactaceae	S	—	—	—
Euphorbia misera	Euphorbiaceae	Sh	0.52	3.98	1.08
Acacia sp.	Fabaceae	T	—	—	P
Cleome isomeris	Capparaceae	Sh	P	P	P
Eriogonum fasciculatum	Polygonaceae	Sh	13.66	1.37	4.63
Simmondsia chinensis	Buxaceae	Sh	1.33	2.57	0.25
Malacothamnus sp.	Malvaceae	Sh	P	—	—
Viguiera laciniata					
Adolphia californica	Asteraceae	Sh	10.74	1.22	0.23
Ambrosia ambrosioides	Rhamnaceae	Sh	P	—	—
Baccharis glutinosa	Asteraceae	Sh	—	—	P
Haplopappus berberidis	Asteraceae	Sh	P	—	—
Haplopappus propinquus	Asteraceae	Sh	P	—	—
Juniperus californica	Cupressaceae	T	P	—	—
Prunus fremontii	Rosaceae	Sh	1.90	—	P
Rhamnus crocea	Rhamnaceae	Sh	0.21	—	—
Rhus ovata	Anacardiaceae	Sh	P	—	—
Artemisia californica	Asteraceae	Sh	8.43	1.09	—
Asclepias subulata	Asclepiadaceae	Sh	0.08	—	—
Dudleya pulverulenta	Crassulaceae	S	P	—	—
Eriodictyon sessifolium	Hydrophyllaceae	Sh	0.24	—	—
Ferocactus viridescens	Cactaceae	S	P	—	—
Fraxinus trifoliata	Oleaceae	Sh	0.12	—	—
Keckiella antirrhinoides	Scrophulariaceae	Sh	P	—	—
Opuntia parryi var. *parryi*	Cactaceae	S	P	—	—
Ribes indicorum	Grossulariaceae	Sh	P	—	—
Sambucus mexicana	Caprifoliaceae	Sh	P	—	—
Baccharis sarothroides	Asteraceae	Sh	P	P	—
Cneoridium dumosum	Rutaceae	Sh	1.04	0.18	—
Malosma laurina	Anacardiaceae	Sh	1.57	0.55	P
Rhus integrifolia	Anacardiaceae	Sh	1.02	P	—
Salvia apiana	Lamiaceae	Sh	0.37	P	—
Salvia munzii	Lamiaceae	Sh	6.90	1.98	—
Ephedra californica	Ephedraceae	Sh	0.13	P	—
Aesculus parryi	Aesculaceae	Sh	1.36	0.37	—
Haplopappus linearifolius	Asteraceae	Sh	0.13	0.26	—
Bergerocactus emoryi	Cactaceae	S	1.75	0.34	—
Rosa minutifolia	Rosaceae	Sh	0.70	12.62	—
Trixis californica	Asteraceae	Sh	0.28	P	—
Dudleya sp.	Crassulaceae	S	P	0.11	P

APPENDIX 1. EXTENDED. CONTINUED.

Plant community										
SCBS	VPDS	RCMS	NVPMS	VFDS	IGCDS	MCDS	BDS	BDW	CGCDS	SGCDS
0.37	—	—	—	—	—	—	—	—	—	—
P	—	—	—	—	—	—	—	0.32	—	—
P	—	—	P	—	—	—	—	—	—	—
7.03	—	6.62	4.17	—	—	0.17	—	—	—	—
P	—	P	—	—	—	—	—	—	—	—
—	—	7.11	—	—	—	—	—	—	—	—
—	—	0.26	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	P	0.28	0.11	—	0.08	P	—	—	—	—
—	—	12.58	3.98	2.30	0.57	0.16	0.27	—	0.12	—
—	—	—	—	—	—	0.95	—	—	—	—
—	—	P	—	—	—	—	—	—	—	—
1.02	—	—	—	—	—	—	—	—	—	—
P	—	—	P	—	—	P	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
1.46	—	—	—	—	—	0.52	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	P	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	1.43	0.37	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	P	—	—	—	—	—	—	—	—
—	—	P	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
P	—	—	—	—	—	—	—	—	—	—
—	—	0.09	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	2.30	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
P	—	—	—	—	—	0.27	—	—	P	—
—	—	1.18	0.27	—	—	—	—	—	—	—

APPENDIX 1. CONTINUED.

Species	Family	General life form	Plant community DCSS	MCSS	CVMS
Myrtillocactus cochal	Cactaceae	S, T	P	1.37	P
Opuntia littoralis	Cactaceae	S	0.13	P	—
Adenostoma fasciculatum	Rosaceae	Sh	0.06	P	—
Atriplex lentiformis	Chenopodiaceae	Sh	—	0.81	—
Ceanothus verrucosus	Rhamnaceae	Sh	—	P	—
Galvezia juncea var. *juncea*	Scrophulariaceae	Sh	—	—	—
Quercus dumosa	Fagaceae	Sh	—	P	—
Lycium brevipes	Solanaceae	Sh	—	1.40	—
Boulders			0.34	0.50	0.55
Unknown woody plants			0.89	0.69	1.99
Bareground/herbaceous			48.70	45.19	63.21

APPENDIX 1. EXTENDED. CONTINUED.

Plant community										
SCBS	VPDS	RCMS	NVPMS	VFDS	IGCDS	MCDS	BDS	BDW	CGCDS	SGCDS
—	—	P	—	—	—	—	P	—	—	—
—	—	P	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	P	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	P	—	—	0.86	—	—	0.30	—	—
2.69	—	—	—	—	—	—	—	—	—	—
2.06	0.91	—	1.46	2.59	0.79	0.86	1.58	3.10	0.70	0.64
65.81	70.96	58.35	66.21	76.86	59.38	65.81	59.31	50.85	61.45	50.63